Class:- 8

Hydrogen Spectrum

Teaching Task

JEE Main Level

Q1) Ans:- B.

Solution:- $\frac{1}{\lambda_1} = R(1)^2\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right]$

$$\frac{1}{\lambda_2} = R(1)^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$$

$$\lambda_1 = \frac{1}{R} \text{ and } \lambda_2 = \frac{16}{3R}.$$

$$\therefore \frac{16}{\lambda_2} = \frac{3}{\lambda}$$

Q2) Ans:- A, B, C

Solution:- Lyman series, of hydrogen.

$$V_1 = R\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] \times 1^2 = R[1] = R.$$

Last line of lymen series of He^+.

$$V_2 = R\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] \times 2^2 = R(4) = 4R.$$

Last line of balmar series of He^+.

$$V_3 = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] \times 2^2 = R\left[\frac{1}{4}\right]4 = R.$$

$$V_1 = V_3, \quad 2(V_1 + V_3) = V_2, \quad 4V_1 = V_2$$

Q3) Ans:- A.

Solution:- $u_1 = R\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = R.$

$u_2 = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = R\left[\frac{4-1}{4}\right] = \frac{3R}{4}.$

$u_3 = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = \frac{R}{4}$

A) $u_1 - u_2 = R - \frac{3R}{4} = \frac{4R-3R}{4} = \frac{R}{4} = u_3$ ✓

B). $u_2 - u_1 = \frac{3R}{4} - R = \frac{3R-4R}{4} = \frac{-R}{4}$ ×

c) $u_3 = \frac{1}{2}(u_1 - u_2) = \frac{1}{2}\left[R - \frac{3R}{4}\right] = \frac{1}{2}\left[\frac{4R-3R}{4}\right]$

$= \frac{1}{2} \times \frac{R}{4} = \frac{R}{8}.$

$u_3 = \frac{R}{4}$. So it wrong.

D). $u_1 + u_2 = R + \frac{3R}{4} = \frac{4R+3R}{4} = \frac{7R}{4}.$

Q4) Ans:- C.

Solution:- $V = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right].$

Here, $n_1 + n_2 = 4$, $n_2 - n_1 = 2$

Solve

$n_2 + \cancel{n_1} = 4$

$n_2 - \cancel{n_1} = 2$

$2n_2 = 6 \rightarrow n_2 = 3$ then $n_1 = 4.$

$V = R\,3^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

$= \cancel{9}R\left[\frac{9-1}{\cancel{9}}\right] = 8R.$

Q5) Ans:- A.

Solution:- For nth excited state $n = (n^{th}+1)$

Here $n^{th} = 3^{rd} = 3+1$.

$n = 4$.

For the first H-atom the possible no. of photons emitted → $4 \to 3$
$3 \to 2$
$2 \to 1$.

For the 2nd H-atom, the possible no. of photons emitted ⇒ $4 \to 2$
$2 \to 1$. (repeated)

∴ The maximum no. of photons emitted → 4.

Q6) Ans:- B, C, D.

Solution:- $n_2 = 5$, $n_1 = 2$

No. of lines belonging to balmer series.

$$\text{No. of spectral lines} = \frac{(n_2-n_1)(n_2-n_1+1)}{2}$$

$$= \frac{(5-2)(5-2+1)}{2}$$

$$= \frac{3(3+1)}{2} = \frac{3(4)}{2} = 6.$$

∵ When in a H-like sample, electrons make transition from 4th excited to 2nd state, then 6 different spectral lines observed
→ Balmer series i.e $5 \to 2$, $4 \to 2$ & $3 \to 2$
→ Paschen series i.e $5 \to 3$, $4 \to 3$.

Q7) Ans:- B.

Solution:- First line of lymen series.

$$\frac{1}{\lambda_1} = R \times 1^2 \left[\frac{1}{1^2} - \frac{1}{\infty}\right]$$

$$\frac{1}{\lambda_1} = R.$$

$$\lambda_1 = x.$$

$$\frac{1}{x} = R \Rightarrow x = \frac{1}{R}.$$

For Balmer series, $n_1 = 2$, $n_2 = 3$.

$$\frac{1}{\lambda_2} = R \times 1^2 \left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$\frac{1}{\lambda_2} = R\left[\frac{1}{4} - \frac{1}{9}\right] = R\left[\frac{9-4}{36}\right] = \frac{5R}{36}.$$

$$\frac{1}{\lambda_2} = \frac{5}{36}\left[\frac{1}{x}\right]$$

$$\lambda_2 = \frac{36x}{5}$$

Q8). Ans:- C

Solution:- Angular momentum $L = n\frac{h}{2\pi}$

For 3rd line of the Balmer $n_2 = 2$, $n_1 = 5$

Initial angular momentum $(n=5) \rightarrow L_1 = 5\frac{h}{2\pi}$.

Final angular momentum $(n=2) \rightarrow L_2 = \frac{2h}{2\pi}$

Change in Angular momentum $\Delta L = L_1 - L_2$

$$= \frac{5h}{2\pi} - \frac{2h}{2\pi}$$

$$= \frac{5h-2h}{2\pi} = \frac{3h}{2\pi}$$

Q9) **Ans:** A

Solution: For $n=4$ only 2 balmer lines are obtained. i.e, $4 \to 2$, $3 \to 2$.

$$K.E = 13 - \frac{13.6}{4^2}$$

$$KE = 12.15\ eV.$$

Q10) **Ans:** A

Solution: $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$n_1 = 1$ & $n_2 = \infty$

$R = 1.097 \times 10^7 m^{-1}$.

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = 1.097 \times 10^7 m^{-1}.$$

$$\lambda = 9.1 \times 10^{-8} m = 91 nm.$$

Q11) **Ans:** A

Solution: The frequency of light emitted for the transition $n=4$ to $n=2$ of helium ion is equal to that H atom will be $n=2$ to $n=1$.

For He^+ ion.

$$\frac{1}{\lambda} = (2)^2 R_H \left[\frac{1}{2^2} - \frac{1}{4^2}\right] = R_H\left(\frac{3}{4}\right)$$

For H atom.

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 4 R_H \left[\frac{1}{2^2} - \frac{1}{4^2}\right].$$

So $n_1 = 2$, $n_2 = 1$.

JEE Advanced Level.

Q1) Ans:- B

Solution:-

A) The marginal line in Balmer series, n=3 to n=2

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] \rightarrow \frac{1}{\lambda} = R\left[\frac{9-4}{36}\right] = \frac{5R}{36}$$

B) Last line of lyman series $\infty \rightarrow 1$.

$n=\infty$ to $n=1$.

c) The marginal line in paschen series n=4 to n=3

$$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] \Rightarrow \frac{1}{\lambda} = R\left[\frac{16-9}{144}\right] = R\left[\frac{7}{144}\right] = \frac{7R}{144}.$$

D). $\lambda = \dfrac{R_H}{\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]}$, $n_2 > 6 \rightarrow$ The humphrey series not written in this way.

Q2) Ans:- B.

Solution:- A) Balmer series belongs to visible region

B) 1st line of lymen series from $2 \rightarrow 1$.

c) 1st line of balmer series $n_1 = 2$, $n_2 = 3$.

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] \rightarrow \frac{1}{\lambda} = R\left[\frac{9-4}{36}\right] = \frac{5R}{36}$$

D) The Energy differences in the lyman series are b/w 13.6 to 10.2ev.

Q3) Ans:- C

Solution:- The wave number $\bar{\nu} = \frac{1}{\lambda}$ is quantised because it depends on the energy levels of the atom, which are discrete

→ Wave number is related to the energy difference b/w two levels (ΔE) via the Rydberg formula, not directly to the velocity of the electron.

Q4) Ans:- D.

Solution:- No spectral lines observed and no energy released when transition in same energy.

Q5) Ans:- C.

Solution:-

1) For He^+ ion, the spectral lines of the balmer series correspond to transitions to n=2, and the energy level are much higher than those of hydrogen due to the increased nuclear charge (Z=2). These transitions result in wavelengths of outside the visible region

2) The Balmer series of the hydrogen atom corresponds to transition to n=2, these lines are primarily in visible range.

3). Lyman series He^+ (Z=2, n=3, n=1.

$$\Delta E = 13.6 \times Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\Delta E = 13.6 \times 4 \left[\frac{1}{1^2} - \frac{1}{3^2}\right] = 48.4 eV.$$

Q6) Ans:- C

Solution:- First line of paschen series in $n_1 = 3$ to $n_2 = 4$ in Be^{+3} ion. , $Z = 4$.

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] \cdot 4^2$$

$$= R\left[\frac{16-9}{\cancel{144}_{9}}\right] \cdot \cancel{16} = \frac{7R}{9}.$$

Q7) Ans:- $\frac{400}{9}$.

Solution:- Marginal line of brackett series is

$n_1 = 4$, $n_2 = 5$.

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{5^2}\right]$$

$$\frac{1}{\lambda} = R\left[\frac{25-16}{400}\right] = \frac{9R}{400}.$$

$$\lambda = \frac{400}{9R} \rightarrow \lambda = \frac{x}{R_H}$$

$$x = \frac{400}{9} = 44.44.$$

Q8) Ans:- 2

Solution:- $\lambda_B - \lambda_L = 59.3\,nm$

$$\lambda_B = \frac{4}{RZ^2} \;\&\; \lambda_L = \frac{1}{RZ^2} \rightarrow \frac{4}{RZ^2} - \frac{1}{RZ^2} = 59.3 \times 10^{-9}\,m$$

$$\frac{3}{RZ^2} = 59.3 \times 10^{-9}.$$

$$Z^2 = \frac{3}{R[(59.3) \times 10^{-9}]} \Rightarrow Z^2 = \frac{3}{1.097 \times 10^{7} \times 59.3 \times 10^{-9}}.$$

$$Z^2 = 4.61 \rightarrow Z = 2$$

Q9) Ans:- 2

Solution:- $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Range :- $120nm = 1.2\times10^{-7}m$, $165nm = 1.65\times10^{-7}m$

For n_2 value of He^+.

$$\frac{1}{\lambda} = 4R\left[\frac{1}{4} - \frac{1}{n_2^2}\right]$$

$\lambda = 120nm$

$$\frac{1}{1.2\times10^{-7}m} = 4R\left[\frac{1}{4} - \frac{1}{n_2^2}\right]$$

$n_2^2 = 16.67$, $n_2 = 4$.

For $\lambda = 165nm$.

$$\frac{1}{n_2^2} = 0.112$$

$n_2^2 \approx 8.93 \Rightarrow n_2 = 3$

The possible n_2 values are 3, 4. Therefore 2 lines of the balmer series fall with in the wavelength range 120nm to 165nm.

Matrix Matching

Q10) Ans:- A) p. B) q c) r D) r.

Solution:-

A) Lymen series $\rightarrow$ p) $\frac{n(n-1)}{2}$, $n=4 \rightarrow \frac{\overset{2}{\cancel{4}}(3)}{\cancel{2}} = 6$ spectral lines formed.

B) Balmer series $\rightarrow$ q) Maximum no. of lines 2

c) In sample of H $5\to2$ transistion $\rightarrow$ r). wave number $\frac{8R}{9}$.

D) In a single isolated H-atom $3\to1$. $\rightarrow$ r) wave number $\frac{8R}{9}$.

Learner's Task

Q1) Ans:- D.

Solution:- When an electron present in the N=4 shell of H atom, then it can make a transition to K=1 shell or L=2 shell or M=3 shell of the atom.

Now if it makes a transition to K shell of H-atom, then it will result in ultraviolet transmission lines (Lymen series). If the electron jumps to L shell, then it will result in visible spectral emission (Balmer series). If the electron jumps to M shell of H atom, then it will result in infrared band (Paschen series).

Q2) Ans:- A

Solution:- $H\alpha$ line balmer series means 3-2 transition

we know, wave number $= R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$= R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$= R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5R}{36}$$

Q3) Ans:- B.

Solution:- Rydberg Constant $R_H = \frac{2\pi^2 Z^2 m e^4 K^2}{ch^3}$

R_H is directly proportional to mass of electron 'm'

So, R_H will become half when mass 'm' will be half.

Q4) Ans:- B

Solution:- $R_H = \frac{2\pi^2 z^2 m e^4 k^2}{ch^3}$.

Z is atomic number which is different for different elements. Therefore, Rydberg constant will be different.

Q5) Ans:- D.

Solution:- In balmer series, the first line is H_α, 2nd line is H_β, 3rd line H_γ and 4th line is H_δ.

For balmer series, n_1 is fixed at 2 and for H_β $n_2 = 4$.

$\boxed{n_1 = 2 \text{ and } n_2 = 4} \longrightarrow \Delta n = 2.$

Q6) Ans:- D.

Solution:- Lyman series is in U.V region.

Q7) Ans:- A

Solution:- Balmer series of lines are observed when electrons jump from any higher energy level to 2nd energy level.

Q8) Ans:- B.

Solution:- Any transition from $n \geq 3$ to $n=2$ in the balmer series will be associated with colored spectral lines.

Q9) Ans:- A

Solution:- Lyman has higher energy.

Q10) Ans:- D

Solution:- The wavelength of a spectral line for an electronic transition is inversly proportional to the difference in the energy involved in the transition.

$$\Delta E = E_2 - E_1 = \frac{hc}{\lambda} \rightarrow \lambda \propto \frac{1}{\Delta E}.$$

Q11) Ans:- B.

Solution:- The total number of lines in the Lyman series of the hydrogen spectrum is $n-1$, where n is the no. of orbits

Q12) Ans:- A.

Solution:- Energy of the hydrogen atom in nth state,

$$E_n = -\frac{13.6}{n^2} \text{ ev}.$$

Here $n=5$

$$\therefore E_n = -\frac{13.6}{5^2} = -0.54 \text{ ev}$$

Q13) Ans:- C

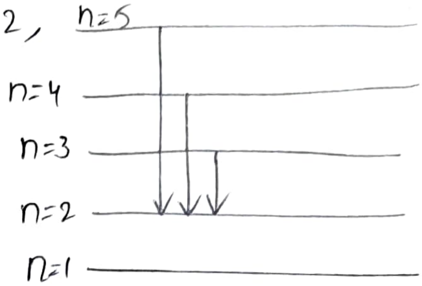
Solution:- As both helium ion and hydrogen has one electron in their outermost shell so both show the same spectrum having similar spectral lines on transitions.

Q14) **Ans:-** C

Solution:- Visible region means, Balmer series.

For balmer ground state $n_1 = 2$,

Given $n_2 = 5$



No. of lines from

$5 \to 2, 4 \to 2, 3 \to 2.$

Total no. of lines = 3

JEE Main Level

Q1) **Ans:-** D.

Solution:- Balmer series, $n_2 \to n_1$

$n_1 = 2, \quad n_2 = 3, 4, 5 \ldots$

$$\bar{\nu} = \frac{1}{\lambda} = R_H Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n^2}\right].$$

For Hydrogen atom $\bar{\nu} = \frac{1}{\lambda} = R_H (1)^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

For 1st line $\quad n_1 = 2, n_2 = 3.$

$$\bar{\nu} = \frac{1}{\lambda} = R_H \left[\frac{1}{2^2} - \frac{1}{3^2}\right] \quad — (1)$$

For Li^{2+} $\quad \bar{\nu} = \frac{1}{\lambda} = R_H (3)^2 \left[\frac{1}{2^2} - \frac{1}{3^2}\right] \quad — (2).$

Substitute (1) in (2).

$$\bar{\nu} = \frac{1}{\lambda} = [\text{wave number of } H] \times 3^2$$

$$= 1500 \times 9$$

$$= 13{,}500$$

$$= 1.35 \times 10^4 \text{ cm}^{-1}.$$

Q2) Ans:- A

Solution:- Highest possible wave length of Lymen series.

$$n_1 = 1,\ n_2 = 2 \ldots$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right] = R_H\left[\frac{4-1}{4}\right] = \frac{3R_H}{4}.$$

$$\lambda_{max.} = \frac{4}{3R_H}$$

For lowest possible wave length of lymen series

$$n_1 = 1,\ n_2 = \infty.$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = R_H$$

$$\lambda_{min.} = \frac{1}{R_H}$$

$$\frac{\lambda_{max}}{\lambda_{min}} = \frac{\frac{4}{3\cancel{R_H}}}{1/\cancel{R_H}} = \frac{4}{3}.$$

Q3) Ans:- B.

Solution:- $\frac{1}{\lambda} = R \times \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Now wave number $= \frac{1}{\lambda}$.

For wavenumber to be R, $\frac{1}{n_1^2} - \frac{1}{n_2^2} = 1.$

This is possible for limiting line of Lymen series ($n=\infty$ to $n=1$)

Q4) Ans:- C

Solution:- In lymen series, 1st line have more energy.

$$n_1 = 1,\ n_2 = 2.$$

$$E = R_H hc(Z)^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

$$= R_H hc(1)^2\left[\frac{4-1}{4}\right] = \frac{3}{4} R_H hc.$$

Q5) Ans:- D

Solution:- H_β line in Balmer series.

$n_1 = 2, \quad n_2 = 4.$

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] z^2$$

$$= R\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = R\left[\frac{4-1}{16}\right] = \frac{3R}{16}$$

$$\frac{1}{\lambda} = \frac{3R}{16}$$

$$\lambda = \frac{16}{3R}.$$

Q6) Ans:- A

Solution:- Energy of the electron in various orbits are Energy in 1st orbit = -13.6ev.

$$E \propto \frac{1}{n^2}$$

2nd orbit $= \frac{-13.6}{4}$ ev $= -3.4$ ev.

3rd orbit $= \frac{-13.6}{9}$ ev $= -1.51$ev

4th orbit $= \frac{-13.6}{16}$ ev $\doteq -0.85$ ev.

→ Electrons is excited to 4th orbit

Lymen n_1 to $n=1$, $n_1 = 3$ [13.6ev − 0.8 ev].

Balmer n_2 to $n=2$, $n_2 = 2$ [12.75 ev]

Paschen n_3 to $n=3$ $n_3 = 1$.

Q7) Ans:- A.

Solution:- We see red end means it is a part of the visible region and obviously only Balmer series corresponds to the visible region for balmer series $n_1 = 2$ and red end means low energy or third end from this means $n_2 = 5$.

$$5 \rightarrow 2.$$

Q8) Ans:- A

Solution:- The emission of visible light involves transition to 2nd orbit as it involve Balmer series from fifth to second table. Thus the excited atom in 2nd orbital, transition must be from $2 \rightarrow 1$ for a atom to its ground state.

Q9) Ans:- C

Solution:- $\frac{1}{\lambda} = R_H Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$.

$\lambda_{Li^{+2}} = \lambda_{He^+}$ $(2 \rightarrow 4$ transition$)$

wavelength of He^+ ion $(Z=2)$

$$\frac{1}{\lambda} = R_H \times 4\left(\frac{1}{4} - \frac{1}{16}\right) \Rightarrow \frac{1}{\lambda} = \cancel{4} R_H \left[\frac{\cancel{4}-1}{\cancel{16}_{4}}\right] = \frac{3R_H}{4}$$

wavelength of Li^{+2} ion $(Z=3)$

$$\frac{1}{\lambda} = R_H \times 9\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right].$$

$$\frac{\cancel{3}R_H}{4} = R_H \times \cancel{9}^{3}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{1}{12}$$

$n_1 = 3,\ n = 6.$

Q10) Ans:- B.

Solution:- For 7th excited state $n=8$.

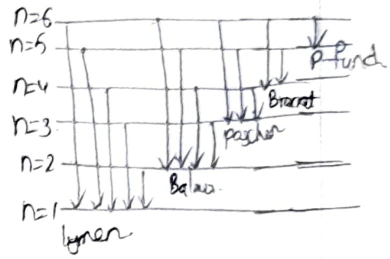
No. of Paschen series = 5

$8 \to 3,\ 7 \to 3,\ 6 \to 3,\ 5 \to 3,\ 4 \to 3$.

Q11) Ans:- C.

Solution:- 5th excited state means $n=6$

No. of spectral lines $= \frac{n(n+1)}{2} = 15$



Paschen, Brackett, pfund series in infrared region

Total 6 lines are in infrared region.

Q12) Ans:- D.

Solution:- The transition $3 \to 2$ will correspond to red line as it has lowest energy.

Red light has minimum energy.

The order of high energy to low energy is VIBGYOR

Q13) Ans:- A.

Solution:- 1st line of balmer series, $n_1=2$, $n_2=3$.

$$\bar{\nu}_B = \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = R\left[\frac{1}{4} - \frac{1}{9}\right] = R\left[\frac{9-4}{36}\right] = \frac{5R}{36}.$$

Last line of paschen series, $n_1 = 3$, $n_2 = \infty$

$$\bar{\nu}_P = \frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{\infty}\right] = \frac{R}{9}.$$

$$\bar{\nu}_B - \bar{\nu}_P = \frac{5R}{36} - \frac{R}{9} = \frac{5R-4R}{36} = \frac{R}{36}$$

Q14) Ans:- A.

Solution:- 5th excited state means $n_2 = 6$.

For lymen series $n_1 = 1$.

No. of lines → $6 \to 1, 5 \to 1, 4 \to 1, 3 \to 1, 2 \to 1$

Total no. of lines in lymen series = 5

Q15) Ans:- D

Solution:- $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Wavenumber and Rydberg's constant have same units.

The lowest energy in Lyman series in 10.4 eV which lies in UV region. So lyman series occur in ultraviolet region.

$$L = \frac{nh}{2\pi}, \quad n = 1$$

$$r = 0.529 \times \frac{n^2}{Z} A^0, \quad n = Z = 1.$$

Advanced Level Questions

Q1) Ans:- A.

Solution:- The H-atom is excited to the 4th level.

Q2) Ans:- D.

Solution:- limiting line in balmer series

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = 364\,nm = 0.364\,mm$$

→ For the balmer series, the lower energy level is $n = 2$

Q3) Ans:- A

Solution:-

Lymen	Balmer	Paschen	Brackett	Pfund	Humphry
$n_1 = 1$	$n_1 = 2$	$n_1 = 3$	$n_1 = 4$	$n_1 = 5$	$n_1 = 6$. $n_2 = 7, 8, 9$.

$$E \propto \frac{1}{n^2}$$

n is high for humphry. So energy is least.

Q4) Ans:- A

Solution:- Last line of Brackett series, $n_1 = 4$, $n_2 = \infty$

$$\frac{1}{\lambda_1} = R\left[\frac{1}{4^2} - \frac{1}{\infty^2}\right]$$

$$\frac{1}{\lambda_1} = \frac{R}{16} \Rightarrow R = \frac{16}{\lambda_1}.$$

2nd line of lymen $n_1 = 1$, $n_2 = 3$.

$$\frac{1}{\lambda_2} = R\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = R\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = R\left[\frac{9-1}{9}\right] = \frac{8R}{9}.$$

$$\frac{1}{\lambda_2} = \frac{8R}{9}$$

$$\frac{1}{\lambda_2} = \frac{8}{9}\left(\frac{16}{\lambda_1}\right)$$

$$\frac{9}{\lambda_2} = \frac{128}{\lambda_1}$$

Q5) Ans:- C

Solution:- 1st line of paschen $n_1 = 3$, $n_2 = 4$.

For Be^{3+} ion $Z = 4$.

$$\bar{\nu} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right]4^2 \Rightarrow \bar{\nu} = R\left[\frac{16-9}{144}\right] \times 16$$

$$\bar{\nu} = \frac{7R}{9}.$$

Integer Type

Q6) Ans:- 5

Solution:- 1st line of balmer series $n_1=2, n_2=3$.

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]\times 1^2$$

$$= R\left[\frac{1}{4} - \frac{1}{9}\right] = R\left[\frac{9-4}{36}\right] = \frac{5R}{36}$$

$$\frac{1}{\lambda} = \frac{xR}{36} \quad \text{so} \rightarrow x = 5$$

Q 7) Ans:- 2

Solution:- Longest wavelength = 130nm

$$\frac{1}{\lambda} = R_h\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$n_1 = 1.$

$$\frac{1}{\lambda} = R_h\left[\frac{n_2^2-1}{n_2^2}\right] \Rightarrow \frac{n_2^2-1}{n_2^2} = \frac{1}{130\times10^{-9}\times109678} = 0.7$$

$n_2 = 2$

Matrix Matching

Q8) Ans:- A) P B) Q c) R D) S.

Solution:-

A) Shortest wavelength in Lymen series → P) $\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] \Rightarrow \frac{1}{\lambda} = R \Rightarrow \lambda = \frac{4x}{5}$

B) Longest wavenlength in lymen serie → Q) $\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = R_H \cdot \frac{3}{4}$.

$\lambda = \frac{4x}{9}$

c) Shortest wavenlength balmer R) $\lambda = \frac{1}{R_H} = 9x$

D) Longest wavelength in Balmer serie S) $\frac{1}{\lambda} = R_H\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$\lambda = \frac{36}{5R_H} = \frac{4x}{27}$

Q9) Ans:- A) P B) Q C) R D) S.

Solution:-

A) Lymen Seriel.	P) $n_2 = 2$ $(n_1 = 1)$.
B) Balmer seriel.	Q) $n_2 = 3$ $(n_1 = 2)$
C) Paschen seriel.	R) $n_2 = 4$ $(n_1 = 3)$
D) Bracket Seriel.	S) $n_2 = 5$ $(n_1 = 4)$.